



# **National Aeronautics and Space Administration**

**Goddard Earth Science Data Information and  
Services Center (GES DISC)**

## **README Document for ACOS Level 2 Standard Product**

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## Revision History

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1 October 2010	Initial Release	C. Avis
20 December 2010	Updates to most sections including changes to ACOS metadata/elements based on the B2.8.00 delivery. Updated quality provided by G.Osterman.	E. Martinez

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# 1 Introduction

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This document provides basic information for using Atmospheric CO<sub>2</sub> Observations from Space (ACOS) Level 2 products. The product details herein are specific to the ACOS system with a *build\_id* of B2.8.00.

The ACOS Level 2 product set consists of products that focus on measuring column-averaged CO<sub>2</sub> dry air mole fraction (*xco2*). The measurements are extracted from observations made by JAXA's Greenhouse gases Observing SATellite (GOSAT). The global coverage that is achieved by GOSAT is repeated every three days at the highest resolution yet achieved from orbit.

The GOSAT team at JAXA produces GOSAT TANSO-FTS Level 1B (L1B) data products for internal use and for distribution to collaborative partners, such as ESA and NASA. These calibrated products are augmented by the ACOS Project with additional geolocation information and further corrections. These ACOS Level 1B products (with calibrated radiances and geolocation) are the input to the ACOS Level 2 production process.

The distribution of GOSAT and ACOS L1B products is currently restricted by cooperation agreements between JAXA and NASA.

## 1.1 Dataset/Mission Instrument Description

The ACOS project is part of the Earth System Science Pathfinder (ESSP) Program in the NASA Science Mission Directorate (SMD). The Orbiting Carbon Observatory (OCO) was to have been the first NASA satellite designed to make global measurements of atmospheric carbon dioxide (CO<sub>2</sub>) sources and sinks on regional scales at monthly intervals. The failure of the launch system and loss of the observatory therefore represented a setback to NASA's carbon cycle and climate science programs.

To meet its stringent CO<sub>2</sub> measurement accuracy requirements, the OCO Science Team developed and implemented several significant advances in ground-based calibration, validation, and remote sensing retrieval methods. These investments were not lost in the OCO launch failure and remain valuable NASA assets. The Japanese GOSAT mission was successfully launched on January 23, 2009. The OCO and GOSAT Science Teams formed a close partnership in calibration and validation activities. JAXA granted the ACOS Project access to GOSAT's calibrated Level 1B measurements. The ACOS Project applies the OCO calibration, validation, and remote sensing retrieval assets to analyze these GOSAT measurements. These analyses generate the Level 2 data products described herein.

The GOSAT prime mission extends five years from the date it was declared operational on April 19, 2009.

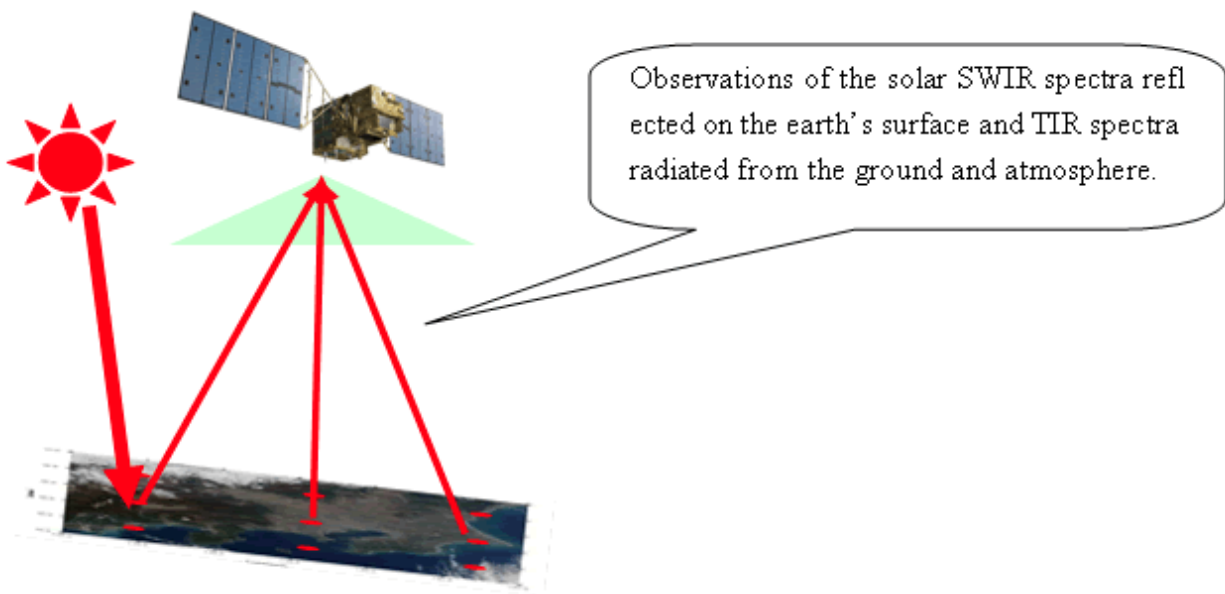
### 1.1.1 Instrument

The primary GOSAT science instrument is the Thermal And Near infrared Sensor for carbon Observation (TANSO). It is a Fourier-Transform Spectrometer (FTS) with 2-axis scanner. The scanner directs light into two sets of detectors within the instrument.

The Short Wave InfraRed (SWIR) detector is designed to measure the spectrum of reflected sunlight from both land and water surfaces. Three spectral regions are covered in two polarizations:

Band 1	.75 - .78 $\mu\text{m}$	Oxygen, a.k.a. ABO2
Band 2	1.56 – 1.72 $\mu\text{m}$	Weak CO2, a.k.a. WCO2
Band 3	1.92 – 2.08 $\mu\text{m}$	Strong CO2, a.k.a. SCO2

The Thermal InfraRed (TIR) detector is designed to measure the spectrum of thermal radiation from both land and water surfaces. A single spectral region is covered (5.5 – 14.3  $\mu\text{m}$ ). The ACOS Level 2 products do not include or utilize any TIR data.



**Figure 1: GOSAT Observation Concept**

#### Orbital parameters

GOSAT nominal orbit parameters are shown below.

- Orbit Type: sun-synchronous, ground track repeat, near-circular orbit
- Recurrent period: 3 days
- Recurrent orbit number: 44

- Revolutions per day: 14+2/3 rev/day
- Local sun time at descending node: 12:45 – 13:15 PM
- Altitude above equator: 665.96 km
- Orbital Period: 98.1 minutes
- Inclination: 98.06 degrees
- Eccentricity: 0.0 (Frozen orbit)
- Longitude at ascending node: Longitude 4.92 degrees west for orbit 1
- Footprint size on ground: 10.5 km circle when NADIR viewing

### Path ID definition

The Path ID identifies the GOSAT orbit tracks on the ground. The detailed characteristics are:

- A path begins at ascending node and extends to the next ascending node
- The ascending node of the Path with an ID of 1 is at longitude 4.92 degrees west
- The path number of the orbit tracks westward sequentially
- Path IDs run from 1 through 44
- Path calculator: [https://data.gosat.nies.go.jp/map/html\\_E/MapPathCalendar.html](https://data.gosat.nies.go.jp/map/html_E/MapPathCalendar.html)

Points	Interval
1	789 km
3	263km
5 (nominal)	158km
7	113km
9	88km

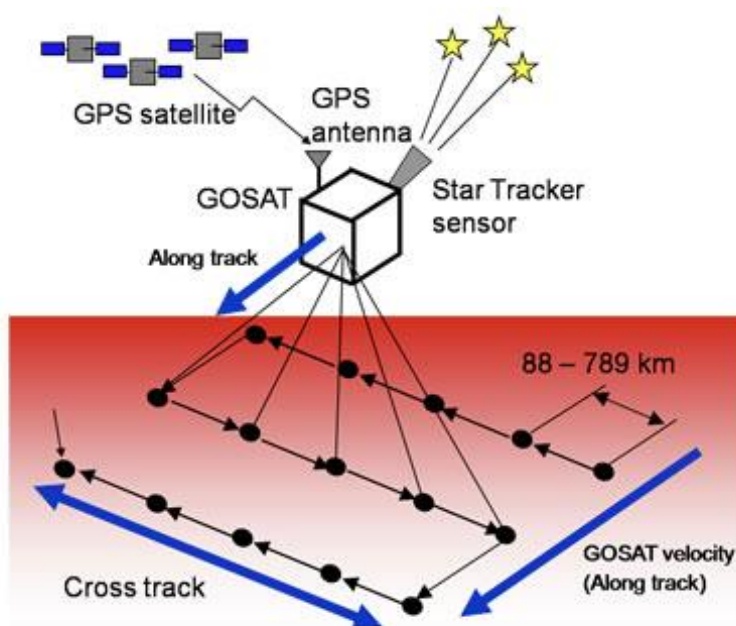


Figure 2: GOSAT TANSO-FTS Observation Details

## 1.2 Algorithm Background

In the sections that follow, the following definitions apply:

- Footprint – an observation by a single instrument
- Sounding – a combined observation of all instruments
- Granule – the construct expressing the content of a product (ACOS product granules contain all the processed GOSAT data for a single orbit)

### Level 1B Algorithm Overview

Radiometric calibration (to Level 1B) of the GOSAT TANSO-FTS data is conducted by the GOSAT team prior to delivery to the ACOS team. The GOSAT team utilizes information from calibration observations, such as, internal light sources, deep space observations and lunar observations. These observations are used either directly for Level 1B calibrations or to establish trends for time-dependent corrections.

Further Level 1B radiometric corrections may be applied by the ACOS team using correction tables provided by the GOSAT team.

Sounding and spacecraft geometric variables are included in the ACOS Level 2 products. Some of the derivation ('geolocation') is performed by the ACOS team based upon standard Earth geoid shape and a high-resolution digital elevation model (DEM) and some is copied from the GOSAT input products.

ACOS does not currently process all soundings in an orbit. Because the thermal IR data is not utilized in ACOS, only the soundings in the daylight portion of the GOSAT orbit are processed. A major change in this version has the processing algorithm supporting data taken over water. In other words, when the *glint\_flag* is true and the data taken is over water, the algorithm will get retrievals. Conversely, when the *glint\_flag* is false and the data taken is over water, the algorithm will not get retrievals.

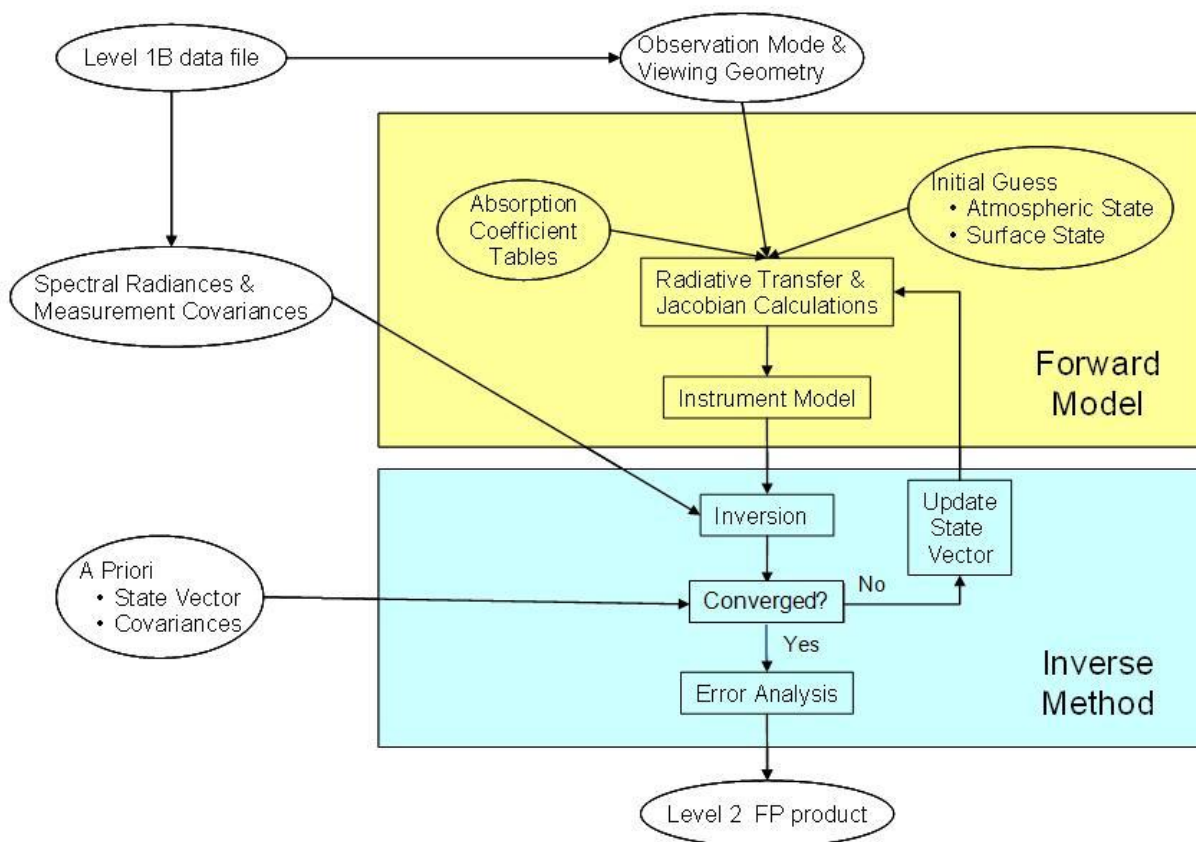
In addition, to restrict the attempted retrievals to those with adequate signal, the soundings are also screened by the expression "*sounding\_solar\_zenith* < 85".

Performing retrievals on scenes containing clouds will either fail or have skewed results (depending upon the extent of cloud coverage). Users should check the *cloud\_flag* for the ACOS estimate of scene cloudiness. Most cloudy scenes will not converge during the processing and, therefore, will not appear in the Level 2 retrieval results.

### Level 2 Algorithm Overview

The Full-physics  $x_{CO_2}$  retrieval algorithm is based on the one that was to be used for the Orbiting Carbon Observatory (OCO). The algorithm is a Rodgers [2000]-type optimal estimation approach and has been described in Connor et al. [2008] and Boesch et al. [2006]. The retrieval

algorithm consists of a forward model, an inverse method, and an error analysis step. The overall flow for the retrieval process is shown in Figure 3.



**Figure 3: Level 2 Full Physics Retrieval Flow**

The basic idea is to use a forward model to simulate all three bands of the OCO-2 spectrum then fitting the measured spectra to the model. The forward model contains components simulating the solar spectrum, atmospheric scattering and absorption, surface optical properties, radiative transfer, and detection by the instrument. The input to the forward model consists of meteorological conditions, surface properties, characteristics of the instrument, etc. Everything that is necessary to fully simulate the as-measured radiances must be input to the forward model.

The residuals between the simulated and measured spectra are minimized by changing parameters in the state vector via the inverse method. This inversion is relatively efficient because the forward model returns not just simulated radiances, but also partial derivatives of those radiances, also called Jacobians. The Jacobians are used by the inverse model to efficiently update the state vector in order to quickly find the state that minimizes the residuals.

Once the atmospheric state yielding the best match to the observed spectrum has been found, the algorithm then determines  $x_{CO2}$ , errors in  $x_{CO2}$  from different sources (such as vertical

smoothing, measurement noise, etc.), and the  $xco_2$  column averaging kernel. This is necessary because  $xco_2$  is not itself an element of the state vector. Rather, it is determined from the profile of  $CO_2$ , which is part of the state vector. It is formally given by the total number of  $CO_2$  molecules in the column divided by the total number of dry air molecules in the column. This step is labeled “Error Analysis” in Figure 3.

### **Validation of the Algorithm (ACOS B2.8 Data Quality Statement)**

This data is the second release of retrieved  $X_{CO_2}$  from GOSAT data by the ACOS project for preliminary evaluation by the broader community beyond the immediate ACOS team. The data now includes ocean glint scenes that are still being evaluated and should be considered as a “preliminary” product.

Initial data validation analyses have been performed on a small subset of the ACOS version 2.8 data (processed for observations taken in July 2009). The data were compared to Total Carbon Column Observing Network (TCCON) ground-based column measurements at 8 different sites ranging in latitude from 53 N to 45 S. From this preliminary analysis, it has been determined that the ACOS  $X_{CO_2}$  retrievals are on the order of 6.5 ppm lower (1.8 to 2.8 ppm standard deviation) than what is measured by TCCON. The bias shows some variation with latitude but is between -5.1 and -8.1 ppm for each of the 8 stations. The data used in the comparisons are a zonal, monthly average using 10 degree latitude bins. The bias between ACOS and TCCON is smaller than it was for the version 2.7 data for the same time period. Preliminary analysis has also shown that the ACOS retrieved surface pressure is typically 10 hPa higher than the ECMWF product. This overestimate of surface pressure accounts for roughly half of the low bias in  $X_{CO_2}$ . Differences between the ACOS 2.7 and 2.8 products also show latitudinal and seasonal variations on the order of 0.5-2.0 ppm for  $X_{CO_2}$  and 1-2 hPa for surface pressure. These differences in the  $XCO_2$  data from the two ACOS builds are largely due to changes in how the GOSAT radiances are calibrated for this release (temporal variations in the calibration).

In comparisons with TCCON data and analysis of a large selection of the ACOS dataset, it is seen that the ACOS data display a significantly higher level of variability than is expected for  $X_{CO_2}$ . The large variability continues to be investigated.

The ACOS data product is still being improved and validation analysis for v2.8 is ongoing. The priority of future releases of ACOS data will be to reduce the biases and other error terms in the  $X_{CO_2}$  product. A more detailed estimate of biases relative to the TCCON network will also be provided with future releases.

See Section 7 for a list of references on this topic.

Build 2.8 contains a master quality flag that provides the data user with information on the quality of each sounding. The data that passed with a “Good” value survived the screens as described in section 2.3.4. These screens will be refined for future data releases.

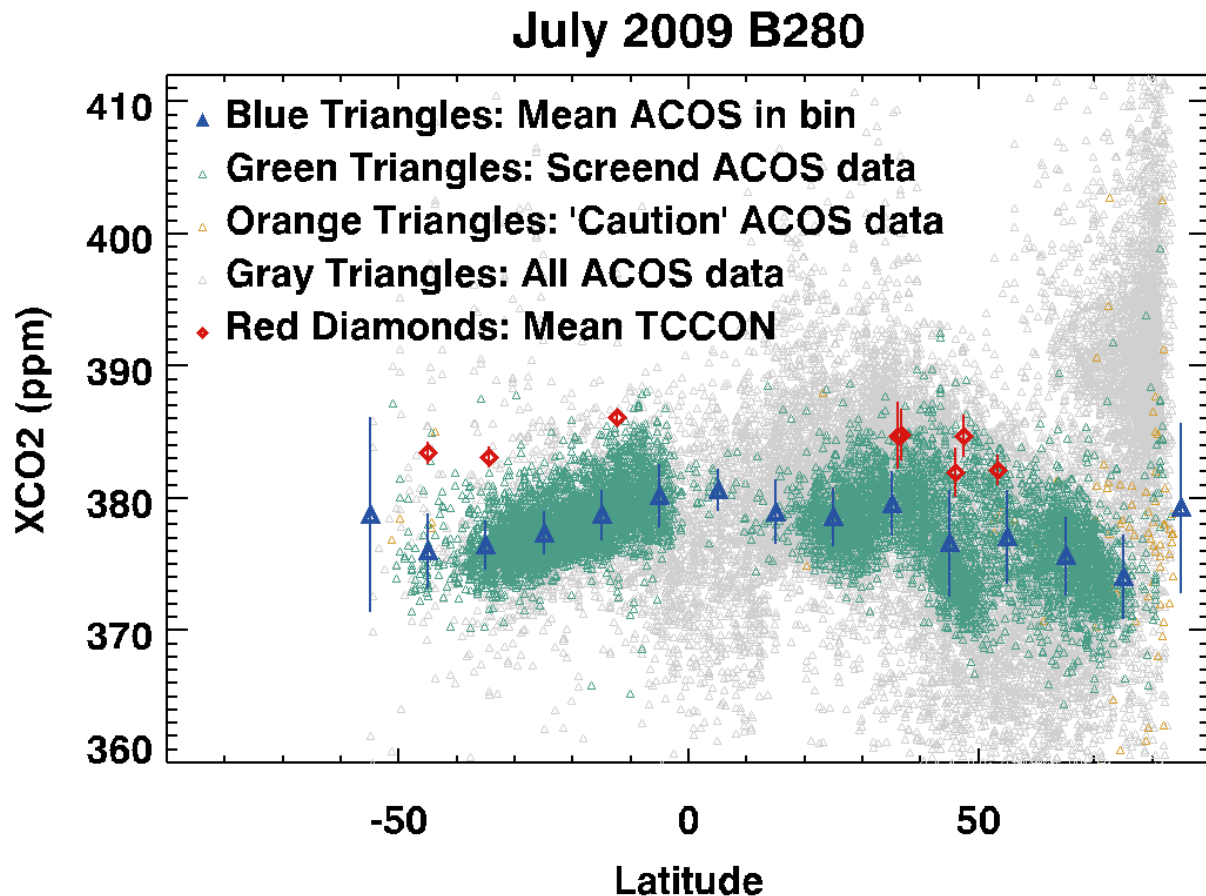


Figure 4: Comparison of mean XCO<sub>2</sub> values from ACOS B2.8 and TCCON for July 2009. The figure shows all the ACOS data (gray), data surviving the Master Quality Flag screen (green) and the mean for 10 degree latitude bins.

### 1.3 Data Disclaimer

The products generated by the ACOS software *build\_id* B2.8.00 have the following characteristics that the user should be aware of:

#### Cloud Screening

- To further reduce the computation time of retrievals containing clouds, the cloud screening algorithm was revised in this delivery. It now performs a fast, Oxygen A-band only clear-sky retrieval for surface pressure, surface albedo, temperature offset and dispersion multiplier. The retrieved surface pressure and albedo information are combined with the X<sub>2</sub> goodness-of-fit statistic and signal-to-noise ratio to determine if a scene is clear(0), cloudy (1), or skipped (2). See Section 7 for a paper on this topic.

### Data Completeness

- The first two months of GOSAT operations (April and May, 2009) have incomplete operational coverage due to on-orbit calibrations and checkout activities. Full coverage begins about 3 June 2009.
- The ACOS Project plans to generate Level 2 products for all available operational GOSAT data (assuming all corresponding ancillary data sets are available).

### Post-Processing

- No bias correction – the retrieval results have not been systematically corrected based upon some known reference source
- No post-screening – the results include all soundings whose retrieval converged. No post-processing filter has been applied to eliminate soundings based upon certain criteria.

### Quality Flagging

- There are several quality flags among the variables. The user should weigh the following information about the flags:
  - *sounding\_qual\_flag* – quality of input data provided to the retrieval processing
  - *outcome\_flag* – retrieval quality based upon certain internal thresholds (not thoroughly evaluated)
  - *master\_quality\_flag* - four possible values: “Good”, “Caution” and “Bad”, and “Failed” as determined from other flags in the L2 product (see Section 2.3.4)

### Averaging Kernels

- The data files include a column averaging kernel value for each retrieved sounding.
- The normalized Averaging Kernel (*xco2\_avg\_kernel\_norm*) for a given pressure level is equal to the non-normalized value (*xco2\_avg\_kernel*) divided by the pressure weighting function at that level.

### Known Problems

- Content issues
  - The unit listed for *xco2*, *xco2\_apriori*, *xco2\_uncert*, *co2\_profile*, *co2\_profile\_apriori*, *co2\_profile\_uncert*, *xco2\_uncert\_noise*, *xco2\_uncert\_noise\_smooth* and *xco2\_uncert\_noise\_interf* is ‘VolumeMixingRatio’. The more accurate unit is  $\text{Mole Mole}^{-1}$ .
- Other
  - Pointers to other files (e.g., ‘InputPointer’) are not useful because those files reside only on the originating system and were not delivered to the GES DISC

### 1.3.1 Contact information

Contact information of the producer of the data products:

ACOS operations team: [gdsops@nephthys.jpl.nasa.gov](mailto:gdsops@nephthys.jpl.nasa.gov)

Contact information for interpretation and usage of the data products:

ACOS data team: [acos@jpl.nasa.gov](mailto:acos@jpl.nasa.gov)

The following list provides references to relevant documentation that users may find helpful.

- General GOSAT information:
  - [http://www.jaxa.jp/projects/sat/gosat/index\\_e.html](http://www.jaxa.jp/projects/sat/gosat/index_e.html)
  - [http://www.gosat.nies.go.jp/index\\_e.html](http://www.gosat.nies.go.jp/index_e.html)
  - [http://www.gosat.nies.go.jp/eng/GOSAT\\_pamphlet\\_en.pdf](http://www.gosat.nies.go.jp/eng/GOSAT_pamphlet_en.pdf)
- Level 2 algorithm information:
  - ACOS Level 2 Algorithm Theoretical Basis Document, JPL D-65488
- Releases and publications:
  - [http://www.jaxa.jp/press/2009/02/20090209\\_ibuki\\_e.html](http://www.jaxa.jp/press/2009/02/20090209_ibuki_e.html)
  - Akihiko Kuze, Hiroshi Suto, Masakatsu Nakajima, and Takashi Hamazaki, "Thermal and near infrared sensor for carbon observation Fourier-transform spectrometer on the Greenhouse Gases Observing Satellite for greenhouse gases monitoring", *Applied Optics*, Vol. 48, No. 35, 10 December 2009

## 2 Data Organization

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The public set of ACOS Level 2 products includes a Standard Product with associated metadata files.

An ACOS Level 2 Standard Product file consists of individual soundings of a single orbit. Each sounding has independent timing, geolocation information and results. Although gathered into orbit granules, no orbit summary or compilation is included. The number of soundings per orbit is variable due to changes in spacecraft modes, land fraction and other factors.

As described in Section 1.1, orbits are identified by Path Numbers. Each path will consistently cover the same geography. Complete coverage of the globe is achieved in three days. Every path will be repeated every three days.

### 2.1 File Naming Convention

ACOS Level 2 Product file name specification:

## **acos\_ttt\_date\_nn\_collection\_productionTimeStamp.h5**

Where:

- ttt = product type (L2s)
- date = observation date (yymmdd)
- nn = GOSAT path number (01-44)
- collection = processing collection identifier (containing the *build\_id*)
- productionTimeStamp = production date/time (UTC) at ACOS (yymmddhhmmss)

Filename example:

*acos\_L2s\_090724\_07\_Production\_v110110\_L2s2800\_r01\_PolB\_101204185614.h5*

By policy, *collection* will contain the software *build\_id*. In addition, *collection* will also contain a data product version *rNN* in case the same product gets regenerated.

## 2.2 File Format and Structure

All ACOS Level 2 product files are in HDF-5 format, developed at the National Center for Supercomputing Applications <http://www.hdfgroup.org/>. This format facilitates the creation of logical data structures.

All ACOS Level 2 product files contain data structures indexed by sounding (1 to N soundings/file) and are associated by the *sounding\_id* variable in all products.

Variables are combined into groups by type (e.g., SoundingGeometry). Within each type, a variable has one or more values per sounding. Variables may be single-valued (e.g., *sounding\_altitude*) or multi-valued (e.g., *co2\_profile*).

The metadata of each variable describes the variable's attributes, such as dimensions, data representation and units.

## 2.3 Key Science Data Fields

### 2.3.1 xco2

The Level 2 Standard Product contains the variable *xco2*. This variable expresses the column-averaged CO<sub>2</sub> dry air mole fraction for a sounding. Those soundings that did not converge will not be present. These values are determined by a full-physics retrieval and have units of mol/mol.

### 2.3.2 cloud\_flag

The Level 2 Standard Product contains the variable *cloud\_flag*. This variable expresses the result of an analysis of the extent of cloud cover within a sounding. Every sounding of a granule will have a value: 0 (Clear), 1 (Cloudy) or 2 (Undetermined). The values are determined by an ABO2-band-only retrieval of the FTS spectrum.

### 2.3.3 surface\_pressure\_fph

The Level 2 Standard Product contains the variable *surface\_pressure\_fph*. This variable expresses the atmospheric pressure at the Earth's surface for a sounding. Those soundings that did not converge will not be present. These values are determined by a full-physics retrieval and have units of pascals.

### 2.3.4 master\_quality\_flag

The intention of this flag is to provide post-processing screening criteria for the Level 2 ACOS XCO<sub>2</sub> retrievals. This flag tells a data user whether a specific retrieval is scientifically usable. There are four possible values: "Good", "Caution", "Bad", and "Failed". The latter case should be rare, but would indicate a problem in the sounding while it was being aggregated into the HDF product.

A "Good" retrieval would need to meet criteria in four areas:

- Cloud screen
- Retrieval success
- Clear sky conditions and surface elevation consideration
- Acceptable algorithm diagnostics

If the retrieval passed the cloud screen and retrieval success tests, but not the final two tests, it would be flagged with a "Caution". If the retrieval did not pass the cloud screen and retrieval success tests it would be flagged as "Bad".

The master\_quality\_flag is created from fields already in the L2 data product. These fields and the screening criteria are as follows:

Retrieval Validity Criteria		
Field Description	HDF Field	Value for Good Retrieval
Cloud Flag	cloud_flag	0
Retrieval Outcome	outcome_flag	= 1 or 2
Chi Squared O <sub>2</sub>	reduced_chi_squared_o2_fph	< 1.2
Chi Squared Weak	reduced_chi_squared_weak_fph	< 1.2
Chi Squared Strong	reduced_chi_squared_strong_fph	< 1.2
Doubtful Sounding Criteria		
Field Description	HDF Field	Value for Good Retrieval
Total AOD Retrieved	retrieved_aerosol_aod_by_type	< 0.15
Surface Pressure Error	surface_pressure_fph – surface_pressure_apriori_fph	0 – 20 hPa 0 – 2000 Pa
XCO <sub>2</sub> a posteriori error	xco2_uncert	< 1.5 ppm
Number of diverging steps	diverging_steps	= 0

**Table 1: Criteria for the L2 master\_quality\_flag**

An additional filter, not included in the master quality flag could also be useful. Filtering data for oxygen (O<sub>2</sub>) A-Band albedo values (albedo\_o2\_fph) less than 0.55 will screen out data that might have problems with clouds over ice.

Note: The criteria in Table 1 and additional criteria such as the A-Band albedo will be updated in future releases with a refined master quality flag.

## 3 Data Contents

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### 3.1 Dimensions

The ACOS Level 2 products contain many variables with a variety of dimensions. The following list describes only the most important of the dimensions.

- Retrieval        - the number of retrievals reported (those soundings for which retrievals converged or were converging when the maximum number of iterations was reached)
- Polarization   - the number of polarization states
- Level            - the number of atmospheric retrieval levels
- Exposure        - the number of scans in granule
- Band            - the number of spectral bands
- Aerosol         - the number of retrieval aerosol types

### 3.2 Global Attributes

In addition to variables and arrays of variables, global metadata is stored in the files. Some metadata are required by standard conventions, some are present to meet data provenance requirements and others as a convenience to users of the ACOS Level 2 Products. The most useful global attributes present in all files are shown in Table 2.

Global Attribute	Type	Description
AscendingNodeCrossingDate	String	The date of the ascending node crossing immediately before the first exposure in the TANSO-FTS file. Format: yyyy-mm-dd
AscendingNodeCrossingTime	String	The time of the ascending node crossing immediately before the first exposure in the TANSO-FTS file. Format: hh:mm:ss.sssZ
StartPathNumber	32-bit integer	The first orbital path on which data contained in the product was collected.
EndPathNumber	32-bit integer	The last orbital path on which data contained in the product was collected.
ProductionDateTime	String	The date and time at which the product was created.

Global Attribute	Type	Description
CollectionLabel	String	Label associating files in a collection.
HDFVersionId	String	For example 'HDF5 1.8.5'. A character string that identifies the version of the HDF (Hierarchical Data Format) software that was used to generate this data file.
BuildId	String	The identifier of the build containing the software that created the product.
TFTSVersion	String	The version of the TANSO FTS data used to create this data product.

**Table 2: Some Global Metadata Attributes**

A list of key metadata fields for each variable can be found in Table 3 below.

Name	Type	Description
Name	String	The name of the variable
Shape	String	The set of dimensions defining the structure
Type	String	The data representation type
Units	String	The units of the variable.
Minimum	String	Smallest valid value of the variable
Maximum	String	Largest valid value of the variable

**Table 3: Key Metadata Items**

### 3.3 Products/Parameters

The ACOS Level 2 Standard Products contain both variables and metadata. The following table describes the metadata.

Metadata					
Element	Shape	Storage	Bytes	Repetition	Comment
InputPointer	InputPtr_Array	String	255	5	The name of the data product that provides the major input that was used to generate this product.
TFTSVersion	Scalar	String	6	1	The version of the TANSO FTS data used to create this data product.
AncillaryDataDescriptors	AncFile_Array	String	255	5	An array of file names that specifies all of the ancillary data files that were used to generate this output product. Ancillary data sets include all input except for the primary input files.
AutomaticQualityFlag	Scalar	String	8	1	Reserved for future use.
CollectionLabel	Scalar	String	255	1	Label associating files in a collection
SizeMBECSDDataGranule	Scalar	Float32	4	1	The size of this data granule in Megabytes.
StartPathNumber	Scalar	Int32	4	1	The first orbital path on which data contained in the product was collected.
StopPathNumber	Scalar	Int32	4	1	The last orbital path on which data contained in the product was collected.
AscendingNodeCrossingDate	Scalar	String	10	1	The date of the ascending node crossing immediately before the first exposure in the TANSO-FTS file. Format: yyyy-mm-dd
AscendingNodeCrossingTime	Scalar	String	13	1	The time of the ascending node crossing immediately before the first exposure in the TANSO-FTS file. Format: hh:mm:ss.sssZ
RangeBeginningDate	Scalar	String	10	1	The date on which the earliest data contained in the product were acquired. Format: yyyy-mm-dd
RangeEndingDate	Scalar	String	10	1	The date on which the latest data contained in the product were acquired. Format: yyyy-mm-dd
RangeBeginningTime	Scalar	String	13	1	The time at which the earliest data contained in the product were acquired. Format: hh:mm:ss.sssZ
RangeEndingTime	Scalar	String	13	1	The time at which the latest data contained in the product were acquired.
ProductionDateTime	Scalar	String	24	1	The date and time at which the product was created.
SISName	Scalar	String	255	1	The name of the document describing the contents of the product.
SISVersion	Scalar	String	8	1	The version of the document describing the contents of the product.
BuildId	Scalar	String	8	1	The identifier of the build containing the software that created the product.
GapStartTime	Gap_Array	String	24	10	Reserved for future use.
GapStopTime	Gap_Array	String	24	10	Reserved for future use.
QAGranulePointer	Scalar	String	255	1	A pointer to the quality assurance product that was generated with

Metadata					
Element	Shape	Storage	Bytes	Repetition	Comment
					this product.
GranulePointer	Scalar	String	255	1	The name of the product.
LongName	Scalar	String	255	1	A complete descriptive name for the product.
ShortName	Scalar	String	16	1	The short name used to identify all data granules in a given data collection.
ProducerAgency	Scalar	String	4	1	'NASA' - Identification of the agency that provides the project funding
ProducerInstitution	Scalar	String	3	1	'JPL' - Identification of the institution that provides project management.
ProductionLocation	Scalar	String	20	1	Facility in which the file was produced: "Operations Pipeline", "Test Pipeline", "SCF", "Preflight Instrument Characterization", "Development", "Orbital", "Unknown"
ProductionLocationCode	Scalar	String	1	1	One-letter code indicating the <i>ProductionLocation</i> . The allowed values are: "" (null string) - Operations Pipeline s - SCF t - Test Pipeline c - Preflight Instrument Characterization d - Development o - Orbital x - Unknown
ProcessingLevel	Scalar	String	8	1	Indicates processing level. The allowed values are: Level 1A, Level 1B, Level 2
InstrumentShortName	Scalar	String	16	1	'TANSO-FTS' - The name of the instrument that collected the telemetry data.
PlatformLongName	Scalar	String	27	1	'Greenhouse gases Observing SATellite'
PlatformShortName	Scalar	String	3	1	'GOSAT'
PlatformType	Scalar	String	10	1	'spacecraft' - The type of platform associated with the instrument which acquires the accompanying data
ProjectId	Scalar	String	3	1	'ACOS' - The project identification string.
DataFormatType	Scalar	String	8	1	'NCSA HDF' - A character string that describes the internal format of the data product.

Metadata					
Element	Shape	Storage	Bytes	Repetition	Comment
HDFVersionId	Scalar	String	3	1	'HDF5 vvvvvvv' - A character string that identifies the version of the HDF (Hierarchical Data Format) software that was used to generate this data file where vvvvvvv is a version id.
NumberOfExposures	Scalar	Int32	4	1	Actual number of points reported in the product
MissingExposures	Band_Polarization_Array	Int32	4	6	Number of expected points missing from the dataset
FirstSoundingId	Scalar	Int64	8	1	The <i>sounding_id</i> of the first sounding in the file
LastSoundingId	Scalar	Int64	8	1	The <i>sounding_id</i> of the last sounding in the file
NominalDay	Scalar	String	255	1	The approximate date on which the data were acquired. A <i>NominalDay</i> starts at an orbit boundary, so the <i>NominalDay</i> for some data do not match their calendar day. Format: yymmdd
OrbitOfDay	Scalar	String	255	1	The ordinal number of the orbit within its <i>NominalDay</i> , starting with 1.
SpectralChannel	Band_Array	String	24	3	The identifier of the spectral regions present in this granule. Allowed values are: '0.76um O2 A-band', '1.6um Weak CO2', '2.06um Strong CO2'
RetrievalPolarization	Scalar	String	1	1	Polarization used in TANSO-FTS measurements in this granule - "P", "S", or "B" (for Both).
L2FullPhysicsInputPointer	L2FullPhysicsInputPtr_Array	String	255	20	List of the input files used by the Full-physics algorithm code
L2FullPhysicsAlgorithmDescriptor	Scalar	String	255	1	A short description of the Full-Physics algorithm that was used to generate this product
L2FullPhysicsDataVersion	Scalar	String	3	1	Indicates the build version number of the Full-physics algorithm used.
L2FullPhysicsExeVersion	Scalar	String	6	1	Indicates the build version number of the Full-physics algorithm used.
L2FullPhysicsOperationsVersion	Scalar	String	6	1	Indicates the build version number of the Full-physics algorithm used.
VMRO2	Scalar	Float32	4	1	The Volume Mixing Ratio of atmospheric O2 in units of Mole Mole <sup>-1</sup>
RetrievalIterationLimit	Scalar	Int32	4	1	Maximum number of iterations allowed in the implementation of the retrieval algorithm
AerosolTypes	Aerosol_Array	String	30	4	Names of aerosol types used in retrievals (e.g., 'total', 'aero1')

Table 4: Level 2 Metadata

The following table describes variables related to the position of the spacecraft at the observation time. Note that the variables have a Shape of 'Retrieval\_Array'. Therefore, soundings are included only when retrievals converged or were converging when the maximum number of iterations was reached.

SpacecraftGeometry								
Element	Shape	Type	Bytes	Repetition	Unit	Min	Max	Comment
x_pos	Retrieval_Array	Float32	4	1	Meters			Spacecraft position in Earth Centered Rotating (ECR) coordinates at the start of the exposure.
y_pos	Retrieval_Array	Float32	4	1	Meters			Spacecraft position in Earth Centered Rotating (ECR) coordinates at the start of the exposure.
z_pos	Retrieval_Array	Float32	4	1	Meters			Spacecraft position in Earth Centered Rotating (ECR) coordinates at the start of the exposure.
x_vel	Retrieval_Array	Float32	4	1	Meters Second <sup>-1</sup>			Spacecraft velocity in Earth Centered Rotating (ECR) coordinates at the start of the exposure.
y_vel	Retrieval_Array	Float32	4	1	Meters Second <sup>-1</sup>			Spacecraft velocity in Earth Centered Rotating (ECR) coordinates at the start of the exposure.
z_vel	Retrieval_Array	Float32	4	1	Meters Second <sup>-1</sup>			Spacecraft velocity in Earth Centered Rotating (ECR) coordinates at the start of the exposure.
spacecraft_lat	Retrieval_Array	Float32	4	1	Degrees	-90	90	Geodetic latitude of sub-spacecraft point at the start of the exposure.
spacecraft_lon	Retrieval_Array	Float32	4	1	Degrees	-180	180	Longitude of sub-spacecraft point at the start of the exposure.
spacecraft_alt	Retrieval_Array	Float32	4	1	Meters			Altitude of the spacecraft above the reference ellipsoid at the start of the exposure.
relative_velocity	Retrieval_Array	Float32	4	1	Meters Second <sup>-1</sup>			The component of the relative SC/Target motion along the look-vector.
ground_track	Retrieval_Array	Float32	4	1	Degrees	0	360	Azimuth of the spacecraft ground track (measured from North)

**Table 5: Spacecraft Geometry Variables**

The following table describes variables related to the instrument look vector or the intersection of the look vector with the Earth surface. Note that the variables have a Shape of 'Retrieval\_Array'. Therefore, soundings are included only when retrievals converged or were converging when the maximum number of iterations was reached.

<b>SoundingGeometry</b>								
<b>Element</b>	<b>Shape</b>	<b>Type</b>	<b>Bytes</b>	<b>Repetition</b>	<b>Unit</b>	<b>Min</b>	<b>Max</b>	<b>Comment</b>
sounding_latitude_geoid	Retrieval_Array	Float32	4	1	Degrees	-90	90	Geodetic latitude of the center of the sounding based on standard geoid
sounding_longitude_geoid	Retrieval_Array	Float32	4	1	Degrees	-180	180	Longitude of the center of the sounding based on standard geoid
sounding_latitude	Retrieval_Array	Float32	4	1	Degrees	-90	90	Geodetic latitude of the center of the sounding based on PGS Toolkit topography
sounding_longitude	Retrieval_Array	Float32	4	1	Degrees	-180	180	Longitude of the center of the sounding based on PGS Toolkit topography
sounding_altitude	Retrieval_Array	Float32	4	1	Meters			Mean altitude of the surface within the sounding based on PGS Toolkit topography
sounding_altitude_max	Retrieval_Array	Float32	4	1	Meters			Maximum altitude of the surface within the sounding based on PGS Toolkit topography
sounding_altitude_min	Retrieval_Array	Float32	4	1	Meters			Minimum altitude of the surface within the sounding based on PGS Toolkit topography
sounding_altitude_uncert	Retrieval_Array	Float32	4	1	Meters			Uncertainty of the measure of altitude of the surface within the sounding based on the accuracy of the input information
sounding_altitude_stddev	Retrieval_Array	Float32	4	1	Meters			Standard deviation of the measure of altitude of the surface within the sounding
sounding_slope	Retrieval_Array	Float32	4	1	Degrees	0	90	Slope of the best-fit plane to the surface within the sounding.
sounding_plane_fit_quality	Retrieval_Array	Float32	4	1	Meters			Standard deviation for the tangent plane approximation
sounding_aspect	Retrieval_Array	Float32	4	1	Degrees	0	360	Azimuth of the surface projection of the slope surface normal
sounding_solar_azimuth	Retrieval_Array	Float32	4	1	Degrees	0	360	Azimuth of the sun at the center of the sounding based on topography
sounding_solar_zenith	Retrieval_Array	Float32	4	1	Degrees	0	90	Angle between the normal to the Earth geoid and the solar angle at the center of the sounding based on topography
sounding_azimuth	Retrieval_Array	Float32	4	1	Degrees	0	360	Azimuth of the vector toward the instantaneous position of the spacecraft from the center of the sounding based on topography
sounding_zenith	Retrieval_Array	Float32	4	1	Degrees	0	90	The angle between the normal to the Earth geoid and the vector toward the instantaneous position of the spacecraft

<b>SoundingGeometry</b>								
<b>Element</b>	<b>Shape</b>	<b>Type</b>	<b>Bytes</b>	<b>Repetition</b>	<b>Unit</b>	<b>Min</b>	<b>Max</b>	<b>Comment</b>
								from the center of the sounding based on topography
sounding_land_fraction	Retrieval_Array	Float32	4	1	Percent	0	100	Percent of land cover within the sounding.
sounding_glnt_angle	Retrieval_Array	Float32	4	1	Degrees	0	180	The angle between the vector to the glint spot and the actual look vector.
sounding_at_angle	Retrieval_Array	Float32	4	1	Degrees	-180	180	Angle between the look vector and the spacecraft Y-Z plane. Positive angle is the right-hand screw direction of the Y-axis.
sounding_ct_angle	Retrieval_Array	Float32	4	1	Degrees	-180	180	Angle between look vector and the spacecraft X-Z plane. Positive angle direction is the right-hand screw direction of the X-axis
sounding_at_angle_error	Retrieval_Array	Float32	4	1	Degrees	-180	180	The difference between AT value derived by MMO and actual one is stored
sounding_ct_angle_error	Retrieval_Array	Float32	4	1	Degrees	-180	180	The difference between CT value derived by MMO and actual one is stored

**Table 6: Sounding Geometry Variables**

The following table describes variables related to the characteristics of the sounding. Note that some of the variables have a Shape including 'Retrieval'. Therefore, soundings are included only when retrievals converged or were converging when the maximum number of iterations was reached. Those variables with a Shape including 'Exposure', however, include all soundings.

<b>SoundingHeader</b>					
<b>Element</b>	<b>Shape</b>	<b>Type</b>	<b>Bytes</b>	<b>Repetition</b>	<b>Comment</b>
sounding_id	Exposure_Array	Int64	8	1	The unique identifier of the sounding.
sounding_qual_flag	Retrieval_Array	BitFlag32	4	1	Single-bit quality flags (see Bit Flags table below)
acquisition_mode	Retrieval_Array	String	4	1	The instrument mode in which the data in the product were collected. Valid values are: 'OB1D', 'OB1N', 'OB2D', 'SPOD', 'SPON', 'CALM', 'LUCA'
ct_observation_points	Retrieval_Array	Int8	1	1	Number of observation points in the cross track direction. -1: undefined or specified observation 0: Electrical Calibration

SoundingHeader					
Element	Shape	Type	Bytes	Repetition	Comment
					"0x01": 1 points "0x03": 3 points "0x05": 5 points "0x07": 7 points "0x09": 9 points
glint_flag	Retrieval_Array	Int8	1	1	Indicates whether GOSAT was in glint mode when acquiring the sounding: -1 – Undetermined 0 – not glint mode 1 – glint mode
exposure_duration	Retrieval_Array	Float32	4	1	The duration of the exposure
sounding_time_string	Retrieval_Array	String	24	1	ZPD time of the sounding, in the format yyyy-mm-ddThh:mm:ss.sssZ
sounding_time_tai93	Retrieval_Array	Float64	8	1	ZPD time of the sounding, in number of SI seconds since midnight, January 1, 1993.
gain_swir	Retrieval_Polarization_Array	String	5	2	Instrument gain setting for each polarization: H - High gain, M - Medium gain, L - Low gain, H_ERR - Error in setting high gain, M_ERR - Error in setting medium gain, L_ERR - Error in setting low gain, UNDEF - Gain set to an undefined state
spike_noise_flag	Retrieval_Band_Polarization_Array	Int8	1	6	0 - No spike noise present, 1 - Spike noise present
zpd_saturation_flag	Retrieval_Band_Polarization_Array	Int8	1	6	Copied from GOSAT L1B exposureAttribute/pointAttribute/RadiometricCorrectionInfo/ZPD_SatiratopmFlag_SWIR
cloud_flag	Exposure_Array	Int8	1	1	Estimate of scene visibility for this <i>sounding_id</i> taken from an ABO2-only clear sky retrieval: 0 - Clear, 1 - Cloudy, 2 - Undetermined
retrieval_index	Exposure_Array	Int32	4	1	Index into the Retrieval dimension of arrays in the RetrievalResults group for soundings

SoundingHeader					
Element	Shape	Type	Bytes	Repetition	Comment
					associated with retrievals.
l2_packaging_qual_flag	Exposure_Array	BitField8	1	1	Bit Flags are used to record the status of each sounding during packaging of l2 output into retrieval arrays

**Table 7: Sounding Header Variables**

The following table describes variables expressing the retrieval results. Note that some of the variables have a Shape including 'Retrieval'. Therefore, soundings are included only when retrievals converged or were converging when the maximum number of iterations was reached.

In the following table,  $xco2$  is calculated in the following way:

$$xco2 = \sum_{i=1}^{N_{num\_levels}} W_i CO2_i$$

where  $W_i$  represents *xco2\_pressure\_weighting\_function* and  $CO2_i$  represents *co2\_profile*. The sum is over *num\_levels*.  $W_i$  is a function primarily of the pressure level spacings, but also weakly of water vapor, and also depends on surface pressure.

RetrievalResults						
Element	Shape	Type	Bytes	Repetition	Unit	Comment
num_active_levels	Retrieval_Array	Int16	2	1		Number of levels in atmospheric model
master_quality_flag	Retrieval_Array	String	8	1		A string field with 4 possible values: "Good" "Caution" "Bad" "Failed" if a problem is seen in the sounding while it is being aggregated into the HDF product.
sounding_id_reference	Retrieval_Array	Int64	8	1		The <i>sounding_id</i> of the sounding containing the spectra used to perform the retrieval

RetrievalResults						
Element	Shape	Type	Bytes	Repetition	Unit	Comment
exposure_index	Retrieval_Array	Int32	4	1		Index into the exposure dimension of arrays in <i>SoundingHeader</i> , <i>SoundingGeometry</i> , and <i>SpacecraftGeometry</i> groups containing the spectra used to perform the retrieval
surface_pressure_fph	Retrieval_Array	Float32	4	1	Pascals	Atmospheric pressure in the lowest of the model levels
surface_pressure_apriori_fph	Retrieval_Array	Float32	4	1	Pascals	Apriori of surface pressure
surface_pressure_uncert_fph	Retrieval_Array	Float32	4	1	Pascals	Uncertainty of surface pressure
vector_pressure_levels	Retrieval_Level_Array	Float32	4	20	Pascals	Pressure altitude corresponding to each atmospheric level
iterations	Retrieval_Array	Int16	2	1		Number of iterations taken to converge
dof_co2_profile	Retrieval_Array	Float32	4	1		Degrees of freedom (target gas profile only)
dof_full_vector	Retrieval_Array	Float32	4	1		Degrees of freedom (full state vector)
outcome_flag	Retrieval_Array	Int8	1	1		Indicator of the quality of the retrieval: 1 = passed internal quality check, 2 = failed internal quality check, 3 = reached maximum allowed iterations, 4 = reached maximum allowed divergence
xco2	Retrieval_Array	Float32	4	1	Volume Mixing Ratio	Column-averaged CO2 dry air mole fraction
xco2_apriori	Retrieval_Array	Float32	4	1	Volume Mixing Ratio	Apriori of column-averaged CO2 dry air mole fraction.
xco2_uncert	Retrieval_Array	Float32	4	1	Volume Mixing Ratio	Uncertainty in column averaged target gas dry air mole fraction
co2_profile	Retrieval_Level_Array	Float32	4	20	Volume Mixing Ratio	Vertical profile of CO2 – the xco2 values in all atmospheric model levels
co2_profile_apriori	Retrieval_Level_Array	Float32	4	20	Volume Mixing Ratio	Apriori of the vertical profile of CO2
co2_profile_uncert	Retrieval_Level_Array	Float32	4	20	Volume Mixing Ratio	Uncertainty of the vertical profile of CO2
xco2_uncert_noise	Retrieval_Array	Float32	4	1	Volume Mixing Ratio	Variance of target gas due to noise

RetrievalResults						
Element	Shape	Type	Bytes	Repetition	Unit	Comment
xco2_uncert_smooth	Retrieval_Array	Float32	4	1	Volume Mixing Ratio	Variance of target gas due to smoothing
xco2_uncert_interf	Retrieval_Array	Float32	4	1	Volume Mixing Ratio	Variance of target gas due to interference
diverging_steps	Retrieval_Array	Int16	2	1		Number of iterations in which the retrieval diverged
xco2_pressure_weighting_function	Retrieval_Level_Array	Float32	4	20		The set of pressure level coefficients that are applied to the retrieved <i>co2_profile</i> to compute the estimated <i>xco2</i>
xco2_avg_kernel	Retrieval_Level_Array	Float32	4	20		Column averaging kernel
xco2_avg_kernel_norm	Retrieval_Level_Array	Float32	4	20		Normalized column averaging kernel - the normalized Averaging Kernel (xco2_avg_kernel_norm) for a given pressure level is equal to the non-normalized value (xco2_avg_kernel) divided by the pressure weighting function at that level.
albedo_o2_fph	Retrieval_Array	Float32	4	1		Representative surface albedo for ABO2 spectral region (the retrieved Lambertian surface albedo at 0.770 $\mu\text{m}$ )
albedo_weak_co2_fph	Retrieval_Array	Float32	4	1		Representative surface albedo for Weak CO2 spectral region (the retrieved Lambertian surface albedo at 1.615 $\mu\text{m}$ )
albedo_strong_co2_fph	Retrieval_Array	Float32	4	1		Representative surface albedo for Strong CO2 spectral region (the retrieved Lambertian surface albedo at 2.06 $\mu\text{m}$ )
retrieved_aerosol_aod_by_type_high	Retrieval_Aerosol_Array	Float32	4	6		Retrieved column-integrated aerosol optical depth for each aerosol type for high altitudes
retrieved_aerosol_aod_by_type_mid	Retrieval_Aerosol_Array	Float32	4	6		Retrieved column-integrated aerosol optical depth for each aerosol type for high altitudes
retrieved_aerosol_aod_by_type_low	Retrieval_Aerosol_Array	Float32	4	6		Retrieved column-integrated aerosol optical depth for each aerosol type for high altitudes
retrieved_aerosol_aod_by_type	Retrieval_Aerosol_Array	Float32	4	4		Retrieved column-integrated aerosol optical depth for each aerosol type

**Table 8: Variables Expressing Retrieval Results**

The following table describes variables related to the analysis of the three spectral regions. Note that some of the variables have a Shape including 'Retrieval'. Therefore, soundings are included only when retrievals converged or were converging when the maximum number of iterations was reached.

In the descriptions below, "Reduced chi squared" is defined as:

$$\chi_r^2 = \frac{1}{N_{chan} - 5} \sum_{i=1}^{N_{chan}} \frac{(y_i - f_i(\hat{x}))^2}{\sigma_i^2}$$

where  $N_{chan}$  is the number of GOSAT channels in the spectral region,  $y_i$  is the radiance value measured by GOSAT in channel  $i$ ,  $\sigma_i^2$  is the square of the uncertainty (or noise) in channel  $i$ , and  $f_i(x)$  is the model of the radiance in channel  $i$ .

SpectralParameters						
Element	Shape	Type	Bytes	Repetition	Unit	Comment
residual_mean_square_o2	Retrieval_Array	Float32	4	1	W cm <sup>-2</sup> sr <sup>-1</sup> (cm <sup>-1</sup> ) <sup>-1</sup>	Root mean squares of residuals
residual_mean_square_weak_co2	Retrieval_Array	Float32	4	1	W cm <sup>-2</sup> sr <sup>-1</sup> (cm <sup>-1</sup> ) <sup>-1</sup>	Root mean squares of residuals
residual_mean_square_strong_co2	Retrieval_Array	Float32	4	1	W cm <sup>-2</sup> sr <sup>-1</sup> (cm <sup>-1</sup> ) <sup>-1</sup>	Root mean squares of residuals
signal_o2	Retrieval_Array	Float32	4	1	W cm <sup>-2</sup> sr <sup>-1</sup> (cm <sup>-1</sup> ) <sup>-1</sup>	the signal level representative of the continuum level for this spectrum.
signal_weak_co2	Retrieval_Array	Float32	4	1	W cm <sup>-2</sup> sr <sup>-1</sup> (cm <sup>-1</sup> ) <sup>-1</sup>	the signal level representative of the continuum level for this spectrum.

<b>SpectralParameters</b>						
<b>Element</b>	<b>Shape</b>	<b>Type</b>	<b>Bytes</b>	<b>Repetition</b>	<b>Unit</b>	<b>Comment</b>
signal_strong_co2	Retrieval_Array	Float32	4	1	$W \text{ cm}^{-2} \text{ sr}^{-1} \{ \text{cm}^{-1} \}^{-1}$	The signal level representative of the continuum level for this spectrum.
relative_residual_mean_square_o2	Retrieval_Array	Float32	4	1		Root mean squares of residuals over signal, i.e. $\sqrt{1/N * \text{Sum}[\text{((MeasuredRadiance - ModelRadiance)/signal)}^2]}$ where N is the number of spectral elements in the band
relative_residual_mean_square_weak_co2	Retrieval_Array	Float32	4	1		Root mean squares of residuals over signal, i.e. $\sqrt{1/N * \text{Sum}[\text{((MeasuredRadiance - ModelRadiance)/signal)}^2]}$ where N is the number of spectral elements in the band
relative_residual_mean_square_strong_co2	Retrieval_Array	Float32	4	1		Root mean squares of residuals over signal, i.e. $\sqrt{1/N * \text{Sum}[\text{((MeasuredRadiance - ModelRadiance)/signal)}^2]}$ where N is the number of spectral elements in the band
reduced_chi_squared_o2_fph	Retrieval_Array	Float32	4	1		Reduced chi squared of spectral fit for ABO2 spectral region
reduced_chi_squared_weak_co2_fph	Retrieval_Array	Float32	4	1		Reduced chi squared of spectral fit for Weak CO2 spectral region
reduced_chi_squared_strong_co2_fph	Retrieval_Array	Float32	4	1		Reduced chi squared of spectral fit for Strong CO2 spectral region
snr_o2_l1b	Retrieval_Polarization_Array	Float32	4	2		Signal-to-noise ratio for ABO2 spectral region . from the L1b processing
snr_weak_co2_l1b	Retrieval_Polarization_Array	Float32	4	2		Signal-to-noise ratio for Weak CO2 spectral region
snr_strong_co2_l1b	Retrieval_Polarization_Array	Float32	4	2		Signal-to-noise ratio for Strong CO2 spectral region

**Table 9: Spectral Parameter Variables**

The following table describes bit definitions for the two variables that are constructed as bit flags.

Bit Flags		
Element	Bit #	Content
l2_packaging_qual_flag	0	Spare
	1	Spare
	2	excluded during sounding selection
	3	skipped due to missing sounding file
	4	skipped due to failed sounding file pre-check
	5	failed due to sounding file read error
	6	Spare
	7	failed due to unexpected packaging error
sounding_qual_flag	0	Radiance calibration 0 = At least one band succeeded at least partially 1 = All three bands failed
	1	Geolocation 0 = Sounding geolocation succeeded 1 = Sounding geolocation failed
	2	Radiance calibration 0 = All three bands succeeded 1 = At least one band failed in at least one color
	3	Sounding geometry 0 = All parameters derived successfully 1 = Derivation failed
	4	Band ABO2 radiance calibration 0 = Successful 1 = At least on one color failed
	5	Band WCO2 radiance calibration 0 = Successful 1 = At least on one color failed
	6	Band SCO2 radiance calibration 0 = Successful 1 = At least on one color failed
	7	Sounding time derivation 0 = Successful 1 = Failed
	8	Derivation of surface parameters using DEM 0 = Successful 1 = Some parameters could not be derived
	9	Spacecraft position and velocity derivation 0 = Successful 1 = Failed
	10-31	Spare

**Table 10: Bit Flag Definitions**

## 4 Options for Reading the Data

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### 4.1 Tools

#### HDFView

HDFView is a Java based graphical user interface created by the HDF Group that can be used to browse all ACOS HDF products. The utility allows users to view all objects in an HDF file hierarchy, which is represented as a tree structure. HDFView can be downloaded or support found at: <http://www.hdfgroup.org/hdf-java-html/hdfview/>.

## 5 Data Services

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GES DISC provides basic temporal and advanced (event) searches through its search and download engine, **Mirador**:

<http://mirador.gsfc.nasa.gov/>

Mirador offers various download options that suit users with different preferences and different levels of technical skills. Users can start from a point where they don't know anything about these particular data, its location, size, format, etc., and quickly find what they need by just providing relevant keywords, like "ACOS", or "CO2".

Information about GOSAT/ACOS data can be researched alongside with other relevant collections in GCMD:

<http://gcmd.nasa.gov/>

or

[http://gcmd.gsfc.nasa.gov/getdif.htm?GES\\_DISC\\_ACOS\\_L2S\\_V002](http://gcmd.gsfc.nasa.gov/getdif.htm?GES_DISC_ACOS_L2S_V002)

## 6 More Information

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The following list is of related organizations, web sites or publications that may be beneficial to the user.

- Japanese Aerospace Exploration Agency:
  - [http://www.jaxa.jp/projects/sat/gosat/index\\_e.html](http://www.jaxa.jp/projects/sat/gosat/index_e.html)
- Japanese National Institute for Environmental Studies:

- [http://www.gosat.nies.go.jp/index\\_e.html](http://www.gosat.nies.go.jp/index_e.html)

## 7 Acknowledgements

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Figures 1 and 2 are taken from the JAXA press release “*Greenhouse Gases Observing Satellite "IBUKI" (GOSAT) "First Light" Acquired by Onboard Sensors*”, February 9, 2009 (JST).

More information about the cloud screening algorithm is available from T.E. Taylor, C. O’Dell, D.M. O’Brien, N. Kikuchi, T. Yokota, T. Nakajima, H. Ishida, D. Crisp, and T. Nakajima, Comparison of cloud screening methods applied to GOSAT near-infrared spectra, IEEE Trans. Geosci. Rem. Sens., February 2011.

References for comparisons of ACOS retrievals of GOSAT data to measurements from the ground based Total Carbon Column Observing Network (TCCON) of Fourier transform spectrometers (FTS):

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